

EFFECTS OF TRADE AND GROWTH ON AIR POLLUTION IN THE AGGREGATED SUB-SAHARAN AFRICA

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Abstract

This paper examines the impacts of trade intensity as measured by the share of exports plus imports in *GDP* and economic growth proxies by the *GDP* per capita on air pollution as measured by *CO*₂ emissions. We focus on Sub-Saharan Africa as a whole during the period 1961-2003 to see how trade intensity and *GDP* per capita growth have impacted *CO*₂ emissions in that zone. We use an Autoregressive distributed lag (ARDL) model to analyze both the short and long-run impacts of these variables on the environment. Our results indicate that in the short-run a 1% increase in economic growth leads to 1.04% increase in *CO*₂ emission thus a degradation of air quality, while a 1% increase in trade intensity account for 0.15% decrease in pollution. Most importantly in the long-run, a 1% increase in *GDP* per capita contributes to 1.8% increase in air pollution while a 1% increase in trade intensity leads to 0.57% decrease in *CO*₂ emission thus beneficial to the environment.

JEL Classification: C2, F18, O13

Keywords: Pollution, Environmental Kuznets Curve, Growth, Trade intensity, ECM.

1 Introduction

Environmental questions have regain interest and more attention during recent years due to climatic problems associated with the increased accumulation of pollution and to the deterioration in the quality of the environment due to human activity. The study of the relationship between pollution and income has mainly focused on investigating the environmental Kuznets curve (EKC) (see Stern, 2004). This so call environmental Kuznets curve originated from Kuznets (1955) who hypothesized in 1954 that income inequality first rises in early years of economic growth and then falls in the

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curse of economic development². Grossman and Krueger's (1991) are those who set up the actual EKC concept. They point out that the level of environmental degradation and per capita income follows the same inverted U-shaped relationship as does income inequality and per capita income in the original Kuznets curve.

This inverted U-shape curve shows that pollution intensity rises with per capita income at the early stages of economic development and falls as per capita income rises beyond some threshold level that could be determined. In effect from the estimated coefficients of the following equation³ $\ln E_t = \alpha + \beta_1 \ln Y_t + \beta_2 \ln Y_t^2 + \zeta_t$, the threshold point could be computed as the exponential of the ratio β_1 over $2\beta_2$. A negative value for the coefficient β_2 confirms the inverted U-shape of the curve.

Empirically the growth-pollution literature studying the relationship between per capita income and pollution per capita (see List, Millimet and Stengos, 2003 and Azomahou, Lasney and Van 2006) for individual countries and groups of countries has found that: (i) at the early stages of economic development pollution intensity rises with per capita income; (ii) but pollution intensity falls as per capita income rises beyond some threshold level (see Grossman and Krueger, 1995 and List and Gallet, 1999, among others).

Methodologically previous studies of the relationships between pollution and income have used cross-sectional or panel data for a sample of developing and developed countries, or single countries. In

² Simon Kuznets delivered the presidential address; entitled "Economic Growth and Income Inequality" at the sixty-seventh annual meeting of the American Economic Association in December 1954". He suggested that as per capita income increases, income inequality also increases at first but then, after some turning point, starts declining. Kuznets believed that the distribution of income becomes more unequal at early stages of income growth but that the distribution eventually moves back toward greater equality as economic growth continues.

³ Where E_t denotes per capita pollution, Y_t denotes per capita income, Y_t^2 indicates square income per capita, ζ_t , is an error term.

contrast in this paper we use an Autoregressive distributed lag (ARDL) model to analyze both the short and long-run relationships between the variables for the Sub-Saharan Africa as a whole, as it is well known that environment is a global phenomenon because pollution in one country necessarily influences neighboring others' atmosphere and even beyond.

Although several pollutants have been considered in the study of the EKC (see Managi, 2006) in this paper we use CO_2 as in Douglas and Selden, 1992. In effect the debate concerning the reduction of carbon dioxide (CO_2) emissions is still active both in developed nations and developing countries. In Sub-Saharan Africa countries where environmental quality is not yet a major preoccupation several capital cities are polluted by the emissions of this gas from imported used vehicles and polluting industries. We could forecast that these emissions will increase in the future as these countries will industrialize by outsourcing old industries from the northern countries.

Our empirical findings indicate that for the aggregated Sub-Saharan Africa area, in the short-run a 1% increase in economic growth leads to 1.04% increase in CO_2 emission, while a 1% increase in trade intensity account for 0.15% decrease in pollution. Most importantly in the long-run, in which we should crucially be interested, a 1% increase in the income per capita contributes to 1.8% increase in pollution while a 1% increase in trade intensity leads to 0.57% decrease in CO_2 emission and thus favorable to air quality.

The remaining of the paper is organized as follows. Section 2 presents the model and the econometric methodology. Section 3 presents the estimations results and final remarks are provided in Section 4.

2. The Model Specification

We adopt a simple model aiming to estimate the following relationship:

$$E_t = F(Y_t, T_t) + \zeta_t \quad (1)$$

where E_t denotes per capita emissions of carbon dioxide (CO_2), Y_t denotes per capita GDP , T_t indicates trade intensity as measured by the share of exports and imports in GDP , ζ_t is a stochastic error term, and t is a year index. Expressing Eq. 1 in a natural logarithm form we have the following long run equation:

$$\ln E_t = \alpha + \gamma_1 \ln Y_t + \gamma_2 \ln T_t + \zeta_t \quad (2)$$

The assumptions concerning the preceding Eq. 2 are that while the GDP per capita is supposed to positively impact the emissions of CO_2 i.e. negatively the environment, the trade intensity variable will negatively impact pollution, thus positively the environment.

The estimation will be performed using an unrestricted general to specific Hendry type error correction model (ECM) where the long run relationship is embedded within the dynamic specification, including the lagged dependent and independent variables as follows:

$$\begin{aligned} \Delta \ln E_t = & \alpha + \gamma_1 \Delta \ln Y_t + \gamma_2 \Delta \ln T_t \\ & + \gamma_3 (\ln E_{t-1} - \alpha_1 \ln Y_{t-1} - \alpha_2 \ln T_{t-1}) \\ & + u_t \end{aligned} \quad (3)$$

This model is re-parameterized in the estimable form:

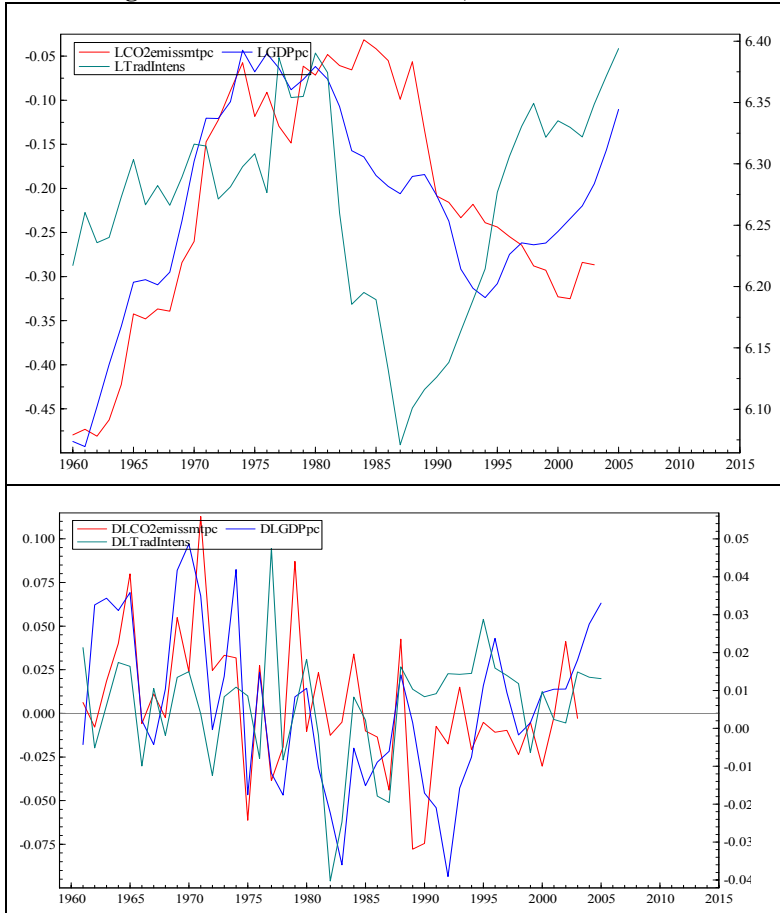
$$\begin{aligned} \Delta \ln E_t = & \alpha + \gamma_1 \Delta \ln Y_t + \gamma_2 \Delta \ln T_t \\ & + \gamma_3 \ln E_{t-1} + \gamma_4 \ln Y_{t-1} \\ & + \gamma_5 \ln T_{t-1} + u_t \end{aligned} \quad (4)$$

3. Data and Results

We estimate the model using data from World Development Indicators (WDI 2006) and covering the period 1960-2005. Figure 1 shows the series in natural logarithm (Top panel) and in first difference (Bottom panel).

The variable $LCO_2emissmtpc$ indicates pollution measured as CO_2 emission (metric ton per capita), $LGDPpc$ indicates Gross domestic product per capita and $LTradIntens$ indicates trade intensity as measured by the share of exports plus imports in GDP.

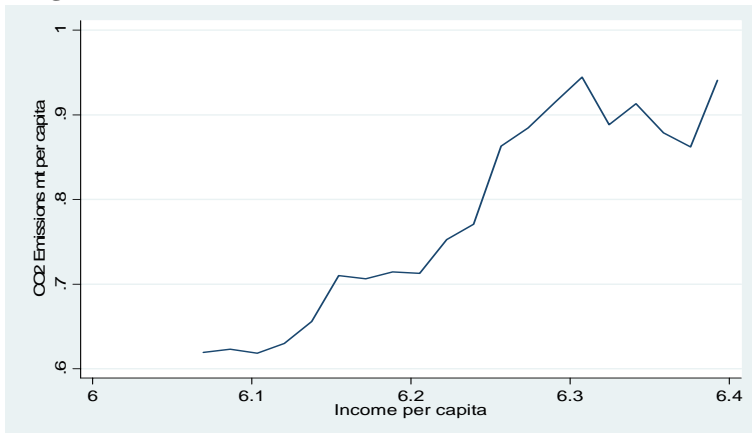
Figure 1: Evolution of Pollution, Trade and Growth



Notes: Pollution in red, Trade in green and Production per head in blue. First graph for levels and second graph for first differences.

From Figure 1 we could distinguish four sub-periods in the relationships between the three variables. The first one spans from 1960 to 1970 where trade intensity and GDPPC are above the pollution. From 1970 to 1980 pollution overcomes trade but not GDPPC. Finally from 1980 to 1995, pollution (CO_2 emissions) overcomes both GDP per capita and trade. Finally since 1996, trade and income per capita are above pollution. This indicates that the SSA data could replicate the EK curve. Figure 2 depicts the environment Kuznets curve expressing the relationships between income growth and the deterioration of environment for sub-Saharan Africa.

Figure 2: Environmental Kuznets Curve (Sub-Saharan Africa)



The curve for Sub-Saharan Africa seems to mimic the first stage of an inverted U-shape curve consistent with the assumption of the theory showing that pollution intensity rises with per capita income at the early stages of economic development, in which these countries are, and falls as per capita income rises beyond some threshold level that could be determined.

In effect from the estimated coefficients of the following Eq. 5:

$$\ln E_t = -69.10 + 20.6134 \ln Y_t - 1.5348 \ln Y_t^2 \quad (5)$$

we computed the ratio $-\left(\frac{\beta_1}{2\beta_2}\right)$. The negative value of $\beta_2 = -1.53$ confirms here the inverted U-shape of the EK curve. Therefore the predicted turning point of the curve in the aggregated Sub-Saharan Africa mean income level could be approximated by $\kappa = \exp\left(-\left(\frac{\beta_1}{2\beta_2}\right)\right) = 824.93$. Most of the Sub-Saharan African countries individual taken are bellow this mean income per capita value and therefore at the first stage of the EKC.

The final estimated dynamic ECM Eq. 4 is reported in Table 1 along with the diagnostic tests and the long-run elasticities of the variables and their t-ratio regarding which all variables are significant. Figure 3 depicts the estimates and residuals. The dynamic ECM equation is reported as follows:

$$\begin{aligned} \Delta \ln E_t = & -2.547 + 1.043 \Delta \ln Y_t - 0.1552 \Delta \ln T_t \\ & - 0.2179 \ln E_{t-1} + 0.3889 \ln Y_{t-1} - 0.1279 \ln T_{t-1} \end{aligned} \quad (6)$$

This equation indicates that in the short run, a 1% increase in the *GDP* per capita enhance CO_2 emissions by 1.043%, while a 1% increase in the trade intensity leads to 0.15% decrease in pollution. The coefficient (-0.2179) in Eq. 6 indicates the speed of the adjustment of the system to the long-run. The long run equation derived from the dynamic ECM is the following:

$$\ln E_t = 1.8 \ln Y_t - 0.57 \ln T_t \quad (7)$$

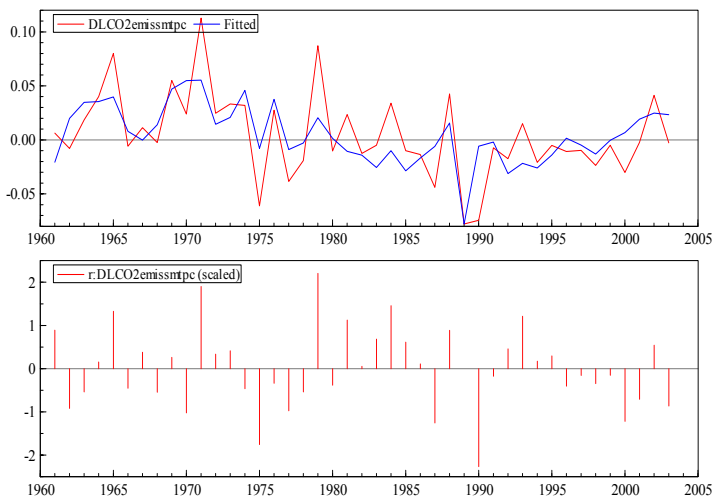
In this long-run equation the *GDP* per capita has a positive sign expressing thus the fact that economic expansion does have a negative impact on environment; whereas the *trade intensity* has a negative sign indicating that trade is beneficial to environment in the aggregated Sub-Saharan Africa area.

Table 1: Model Estimation, OLS 1961 to 2003 (Dependent variable: DLCO2emissmtpc)⁴

	Coefficients	Std. Error	t-value
Constant	-2.54730	1.123	-2.27
DLGDPpc	1.04251	0.2705	3.85
DLTradIntens	-0.155187	0.1323	-1.17
LCO2emissmtpc_1	-0.217913	0.1072	-2.03
LGDPpc_1	0.388865	0.1706	2.28
LTradIntens_1	-0.127946	0.08877	-1.44
DUM89	-0.0749316	0.0329	-2.28
sigma	0.030251	RSS	0.0329444211
R ²	0.475991	F(6,36) =	5.45 [0.000]**
log-likelihood	93.2295	DW	2.01
no. of observations	43	no. of parameters	7

Note: LGDPpc_1 indicates the log of GDPpc one period lag. DUM89 is a dummy variable.

Figure 3: Estimates and Residuals



⁴ Estimations are performed using PcGive 10 (Hendry and Doornik 2001).

4 Final Remarks

This paper has examined the impact of economic expansion as measured by the GDP per capita growth and the trade intensity proxies by the share of imports plus exports in the GDP on pollution as measured by CO_2 emissions in SSA over the period 1961-2003. These relationships are analyzed using an autoregressive distributed lag ECM approach. We find diverse impacts of economic expansion and trade intensity on pollution. In the short run an increase in GDP per capita enhances CO_2 emissions while trade intensity negatively impacts pollution. In the long run, the effect of economic expansion on pollution is positive. On the other hand the impact of trade intensity on CO_2 emissions is negative.

These findings suggest that economic expansion in Sub-Saharan Africa does have a significant and negative impact on environment as predicted by the theory of the environment Kuznets curve. But more importantly, the intensity of trade, which is an aspect of the increasing globalisation phenomenon of Sub-Saharan Africa economies, does have a significant and beneficial impact on the environment in this zone. While international trade favours, the growth of GDP per capita degrades environment.

The beneficial aspects of the trade intensity on the reduction of pollution should be considered by policymakers concerned with new growth strategies in the Sub-Saharan Africa, as a clean source of economic growth. In the same time, the economic expansion by other sources generating pollutants should tend to be regulated by rules limiting atmospheric emissions as its impacts on the environment in this zone are negative. Further investigations should extend this paper to individual Sub-Saharan African countries, and use an alternative multivariate VAR approach which could allow to analyze the interactions between the tree variables, as pollution and trade could have an impact on the growth process and reciprocally.

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